Axion monodromy inflation with modulation corrections

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[2] JCAP10 (2014) 025

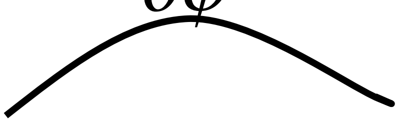
§ Introduction

Inflation solves [Guth, Sato … (1981)]

- the flatness problem
- the horizon problem
- …

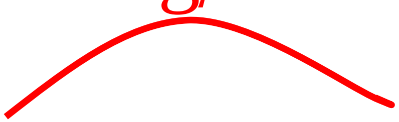
provides

- seeds of the density perturbation $\delta\phi$



  [Hawking, Starobinsky, Guth and Pi (1982)]

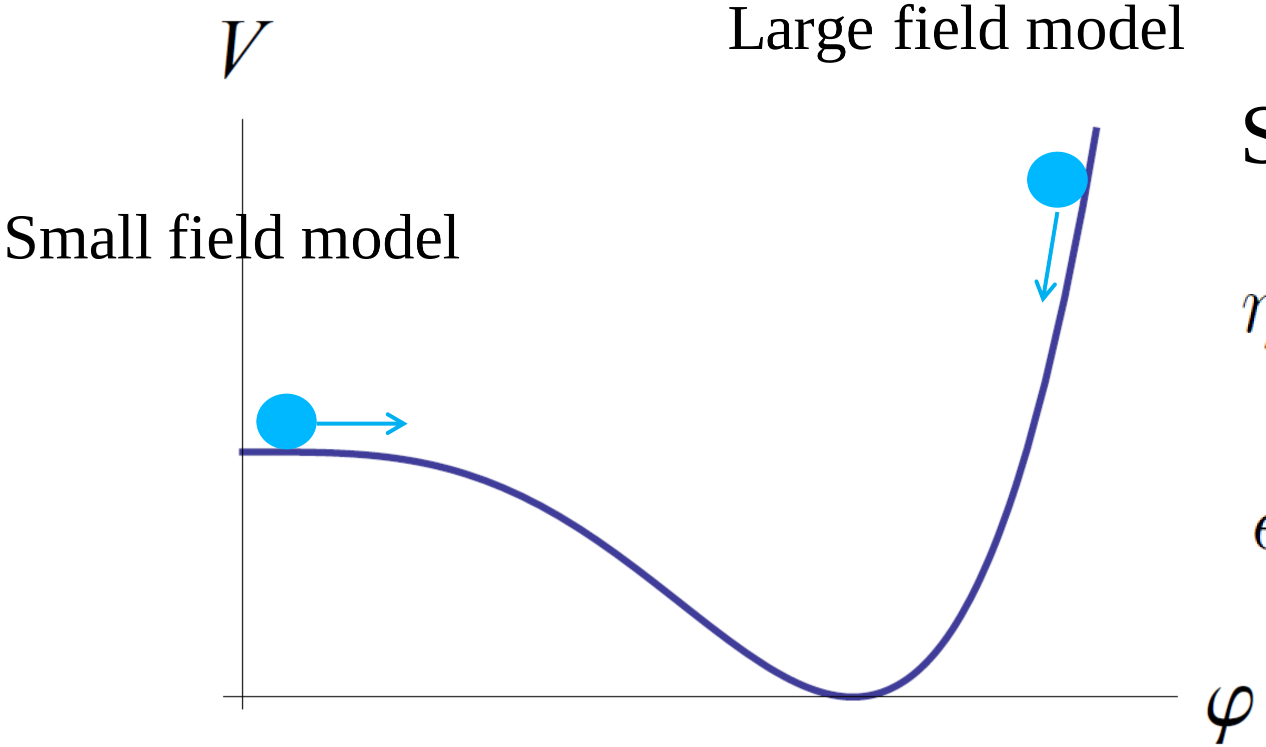
- gravitational wave background $\delta g_{\mu\nu}$



  [Starobinsky (1979), Rubakov et al (1982)]

§ Slow roll inflation

- Potential for *inflaton* needs to be flat



Slow roll param.

$$\eta = \frac{V_{\varphi\varphi}}{V},$$

$$\epsilon = \frac{1}{2}\left(\frac{V_{\varphi}}{V}\right)^2,$$

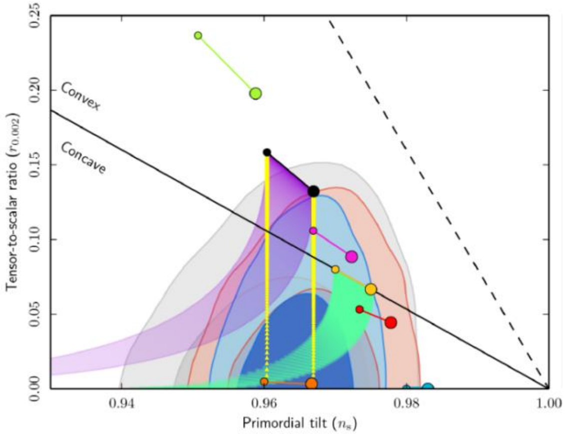
Large field model…

- The potential have a functional form as

  $V \sim \phi$^n

- The inflaton field displacement is much larger than the Planck scale

  $\Delta\phi \gg M_P$



- Lyth bound [Lyth (1997)]

  $\Delta\phi \sim$ (r/8)^½ N

  $= \mathcal{O}(10)$ for (N, r) ~ (50-60, 0.1)

- What keeps the potential flat for such a large field value region?

§ Inflation
by axion or with shift symmetry

- Shift symmetry is powerful to kill higher order terms of inflaton
- If theory is invariant under $\phi \longrightarrow \phi + i\,C$,

  then the potential V = V(... , Im[ϕ])
- Flat for the Im[ϕ] direction.

- Its breaking at a scale f
- Then, V = V(Im[ϕ]/f)

§ Inflation
by axion or with shift symmetry

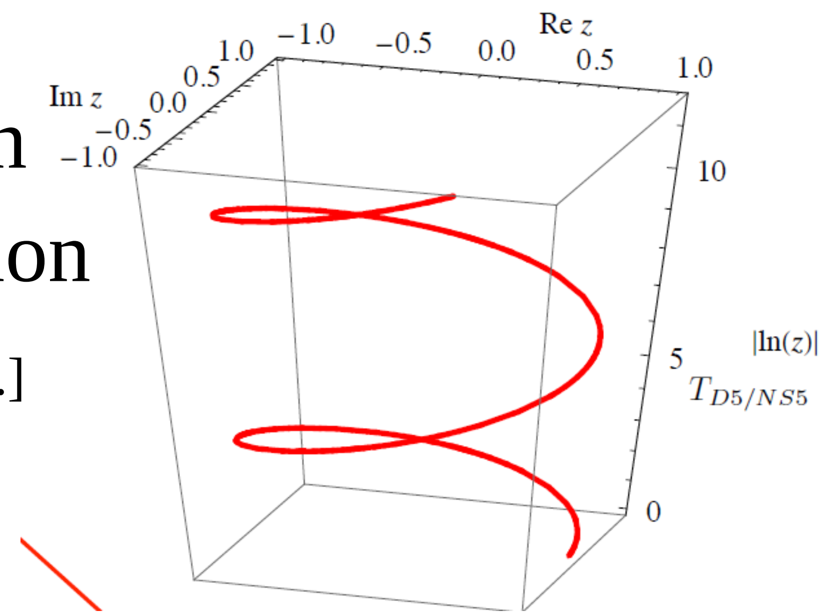
- Narural inflation [Freese et al (1990)]

  $V = V_0\,(1 - \cos(\phi/f\,)\,)$

String theoretical realization

- Axion monodromy inflation

[Silverstein et al, McAllister et al (2008), ...]



[from Westphal's talk file]

§ Inflation
by axion or with shift symmetry

- Axion monodromy inflation
- With 5-brane DBI action,

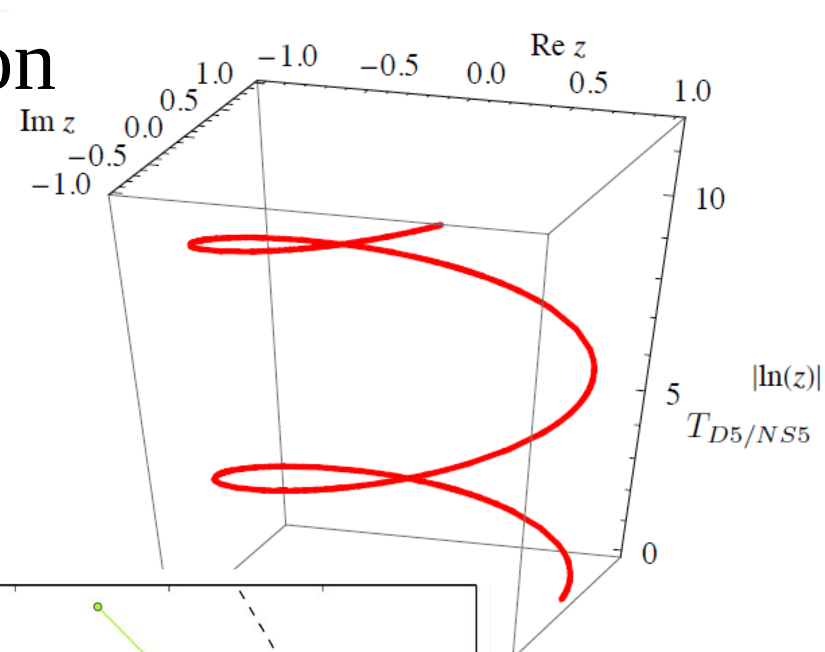
$$S \sim \int dV_6 \sqrt{\det(G + B)}$$

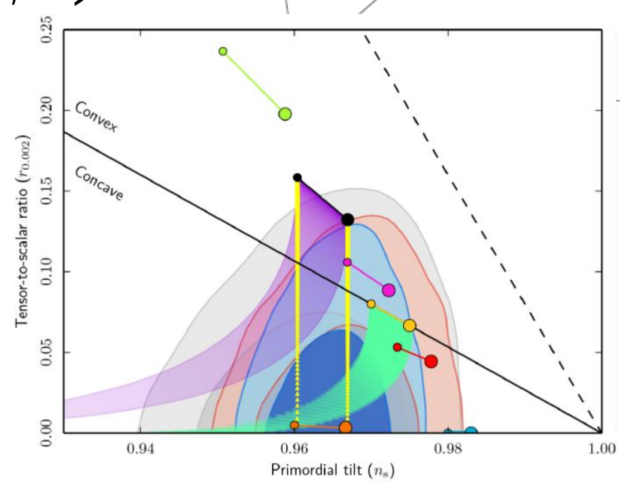
compactify

$$= \int dV_4 \sqrt{(-g)(v^2 + \phi^2)}$$

$$\Longrightarrow V = M^3 \sqrt{(v^2 + \phi^2)}$$

linear at large ϕ





§ Axion monodromy inflation with corrections

Total potential might be [McAllister et al (2008)]

$$V = M^3 \sqrt{(v^2 + \phi^2)} + V_0 \cos(\phi/f) + \ldots$$

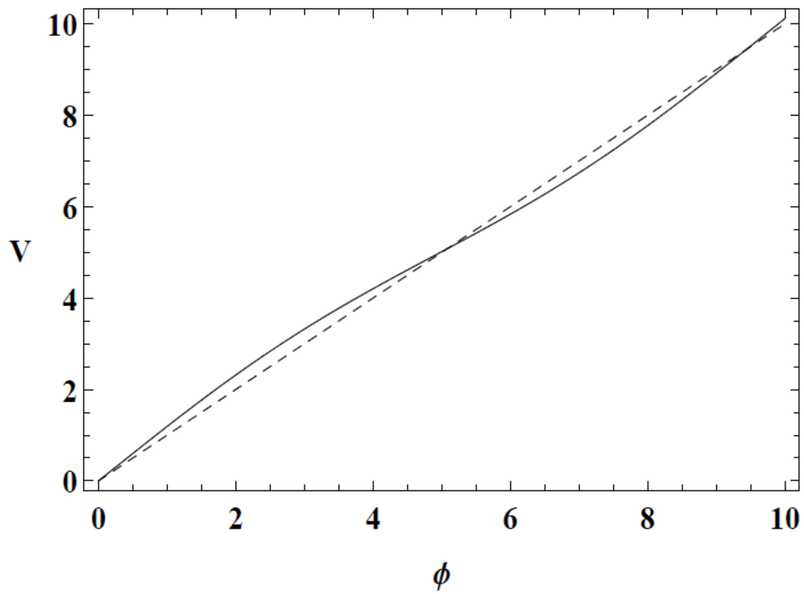
instanton effects

We evaluate inflationary observables.

§ § Axion monodromy inflation with one correction [1]

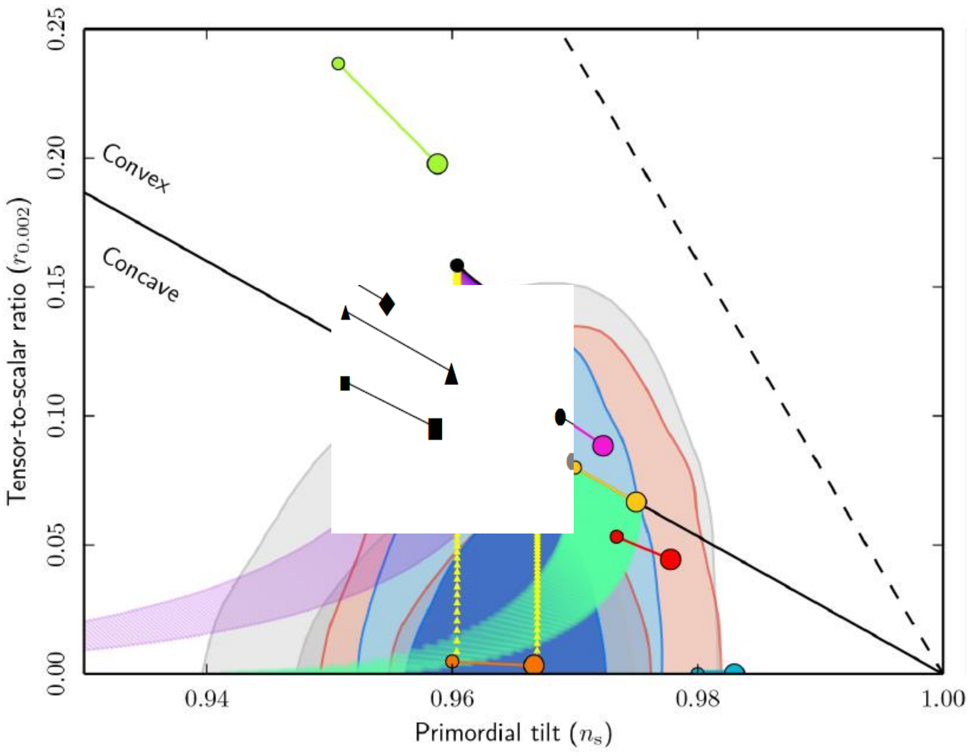
Total potential

$$V = a_1\phi + a_2 \cos\left(\frac{\phi}{f} + \delta\right) + v_0$$



§ § Axion monodromy inflation with one correction [1]

Tensor and spectral index



One sin correction

⟹large tensor and
reduce ns too much

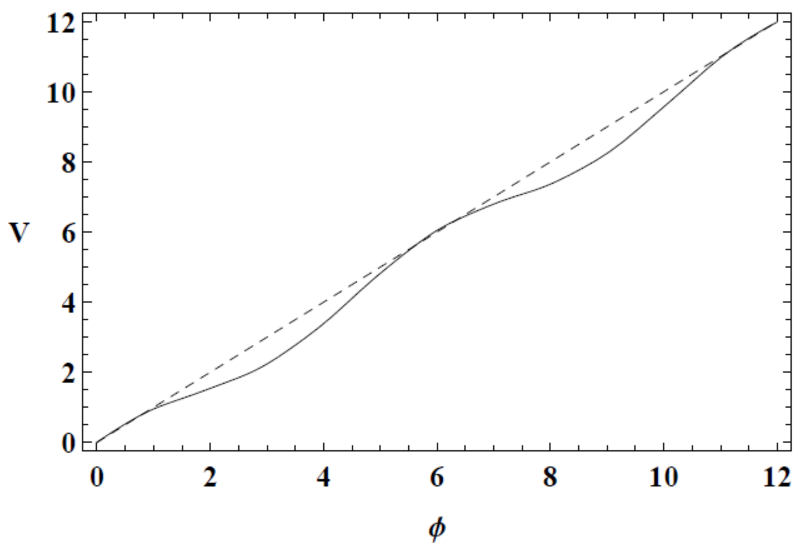
⟹correct ns by η

then α_s is tiny positive

§ § Axion monodromy inflation with two correction terms [2]

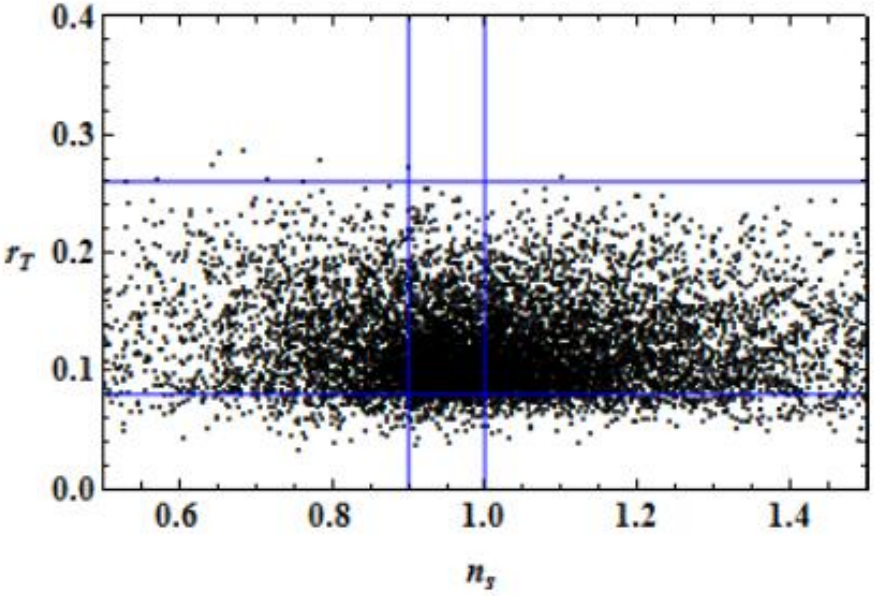
We might have multiple nonperturbative corrections.

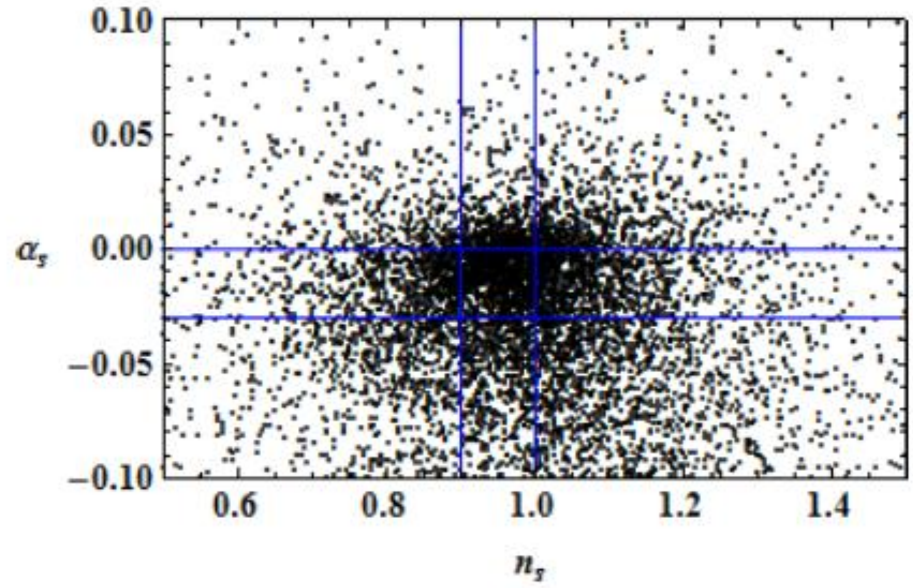
$$\begin{aligned} V &= V_{\mathrm{monodromy}}(\phi) + V_{\mathrm{modulations}}(\phi) \\ &= a_1\phi + a_2\cos\left(\frac{\phi}{f}+\delta\right) + a_2'\cos\left(\frac{\phi}{f'}+\delta'\right) + v_0, \end{aligned}$$



§ § Axion monodromy inflation with two correction terms [2]

Scatter plot in n_s-r plane for varying parameters (e.g, $a_2/(a_1 f)$, …) with the fixed parameter (ϕ=10, ↔ N~50).

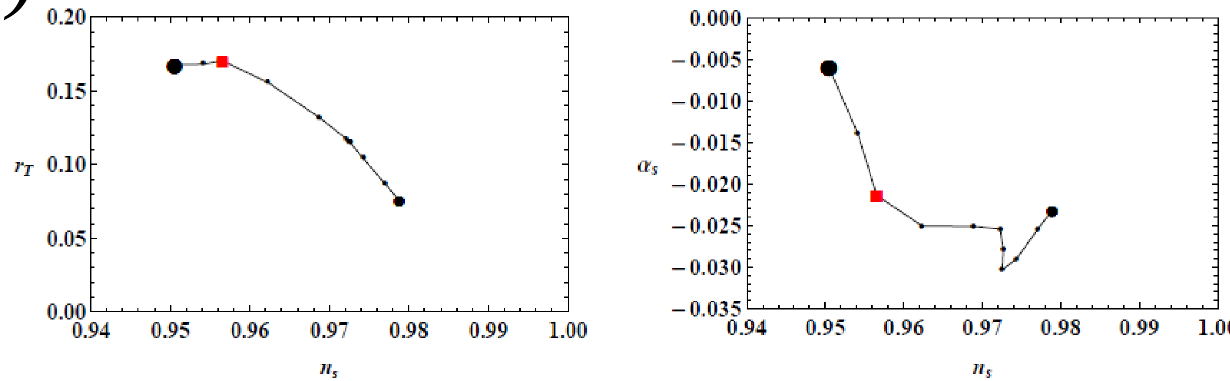


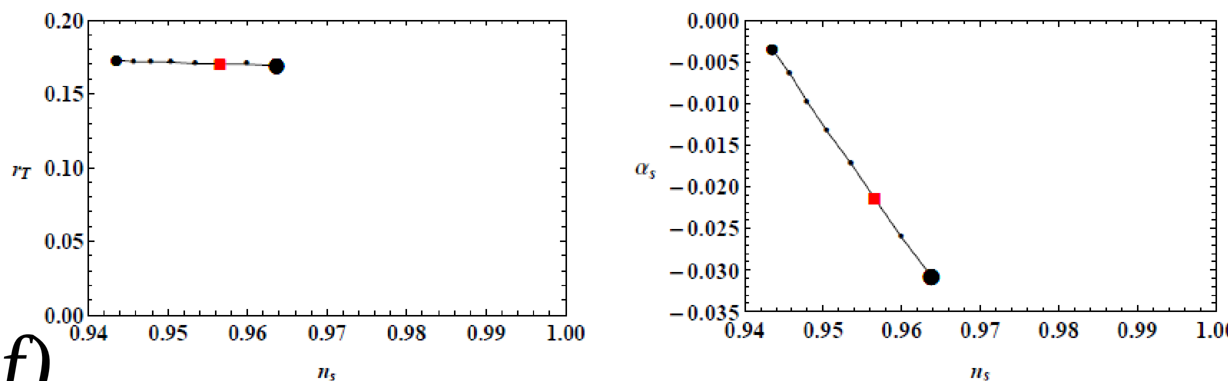


§ § Axion monodromy inflation with two correction terms [2]

Parameter dependence

varying $a_2/(a_1 f)$





varying $a'_2/(a_1 f)$

§ Summary

- Axion monodromy inflation is interesting.
- We calculated the tensor to scalar ratio, spectral index and its running including nonperturbative corrections.

- Nonperturbative corrections give significant changes in inflationary observables.